

CHARACTERISTICS OF THE NEW CALEDONIAN HUMPBACK WHALE POPULATION

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Data collected from 1995 to 2000 in the lagoon of New Caledonia show that between June and November this area is used as a breeding and calving ground for humpback whales, with peak abundance in August. Analyses of photo-identification data and acoustic recordings suggest that this population is a component of the Area V stock. To date, 206 humpback whales have been individually identified. Photo-ID comparisons prove migratory movements between New Caledonia and each of eastern Australia, New Zealand and Tonga. The constant increase in re-sightings of individuals from 1996 to 1998 suggests that the population is not large with an estimate of 314 (± 72) using a weighted mean of the Petersen estimate. Crude birth rate was calculated at 3.4-10% per year. The most commonly encountered pod types were singles (39%) and pairs (31%). Occurrences were greater in August and July. Reproductive groups (16%) and cow and calf pairs (11%) were most often observed in August. Size structure of the population was dominated by large whales (83%). A maximum length of stay of 60 days was observed for a male. A sex-ratio of 1.9:1 in favour of males was calculated. Numbers observed in 1999 were low as were reproductive groups.

□ *Humpback whale, New Caledonia, population estimate, social structure, migration.*

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In New Caledonia the arrival of the humpback whale (*Megaptera novaeangliae*) has long been recorded in the Melanesian calendar, and is an important component of traditions and legends (Garrigue & Greaves, 1999). First documented occurrences of humpback whales in New Caledonian waters come from whaling records of the 19th Century (Townsend, 1935; Pisiert, 1975). While some whaling occurred at Lifou and Maré in the Loyalty Islands east of New Caledonia, it appears that it was more concentrated in the Chesterfield Islands in the Coral Sea to the west. Anecdotal reports suggest that humpback whales frequented New Caledonia until at least the 1950's, prior to the collapse of all Southern Hemisphere stocks.

In the course of initial field observations and photographic identification of humpback whales during a five day survey in 1993 and a two week survey in 1994, Gill et al. (1995) observed behaviour associated with reproductive activity. This, in addition to the presence of mother and calf pairs, suggested that New Caledonia is a reproductive area for this species (Garrigue & Gill, 1994). This preliminary research identified New Caledonia as a winter migratory destination for Area V humpback whales.

To improve knowledge of this population, surveys of two months duration were conducted

annually from 1995 and those results are presented in this paper.

METHODS

STUDY AREA. New Caledonia is part of Melanesia, situated in the southwest Pacific Ocean just north of the Tropic of Capricorn, east of Australia and northwest of New Zealand (Fig. 1). It occupies 1,450,000km² lying between 18°-23°S and 158°-172°E. Grande Terre, the main island of the archipelago, is 400km long and 50-80km wide. It is surrounded by over 1,600km of barrier reef that delineates a lagoon of 24,000km² with a mean depth of 24m. Two groups of small islands are inside this lagoon, the Belep Islands to the north, and the Isle of Pines to the south. Outside the lagoon to the east are the Loyalty Islands: Maré, Lifou and Ouvea. This study was conducted in the southern part of the lagoon, off the main island of Grande Terre.

STUDY PERIODS AND SURVEY METHODS. Since 1991, forms have been distributed to professional and recreational boat users throughout New Caledonia to obtain general information on observations of marine mammals (Garrigue & Greaves, 2001).

Since 1995 we conducted two- to three-month field surveys between July and September in the

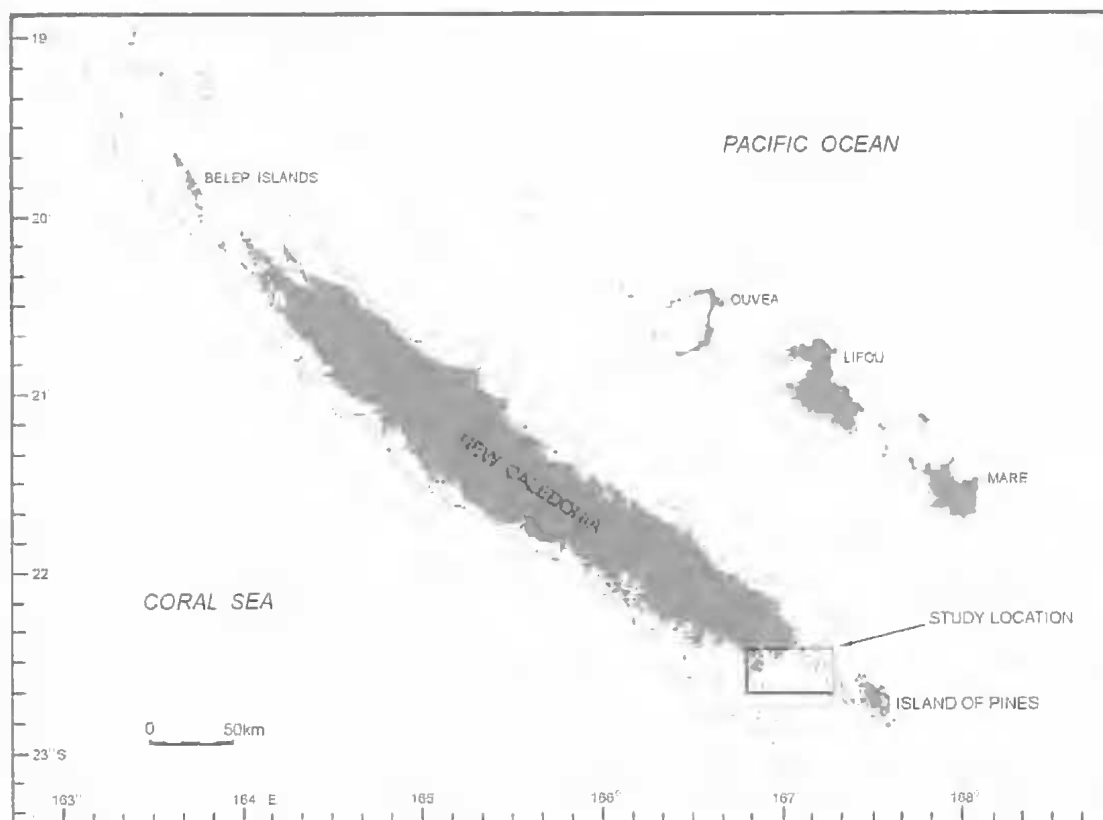


FIG. 1. Islands of New Caledonia, and study region.

southern lagoon between $22^{\circ}20'S$ - $22^{\circ}40'S$, and $166^{\circ}50'E$ - $167^{\circ}07'E$, covering approximately $1,000\text{km}^2$.

During these dedicated surveys, a land-based team searched for whales from an elevated point (189m) using hand-held binoculars ($7 \times 42\text{mm}$) and a telescope. Position and behaviour of pods were recorded and transmitted via VHF radio to a research vessel. Boat-based observations were carried out mainly from a 6m semi-rigid inflatable equipped with two 40hp outboard motors.

Surveys were conducted on all days, weather conditions permitting (wind <20 knots and no rain). There was no *a priori* selection of whale groups of a specific size or composition.

For each observed pod, the time, location (GPS position), group size, pod composition and behaviour were noted. Pod composition included: single, pair, mother and calf, mother-calf and escort, and competitive group, following the definitions of Tyack & Whithead (1983), Baker & Herman (1984) and Clapham et al. (1992). Data were recorded on micro-cassette recorders,

and transcribed each night onto data forms for later database entry.

Individual humpback whales were photographed as often as possible for identification through unique markings on the ventral surface of the tail flukes (Katona et al., 1979). SLR cameras equipped with 200 and 300mm lenses and 100 or 400ASA slide film were used for photo-identification.

Tissue samples were collected using a cross-bow and specially adapted bolt (Lambertsen et al., 1994.). Skin was placed in ethanol and fat was wrapped in pre-heated (550°C) aluminium foil. Samples were then deep frozen for later analyses. Humpback whale songs were recorded using a hydrophone with preamplifiers and an analogue cassette tape recorder (Sony WM-D6C).

DATA ANALYSIS

Whale occurrence, the composition of pods and size of individuals were recorded. Gender was identified by amplification of the male specific gene SRY (Gilson & Syvanen, 1998).

TABLE 1. Sampling effort and number of humpback whales sighted from sea- and land-based surveys.

Year	Month	Study effort					Sightings			
		Sea-based			Land-based		Sea-based		Land-based	
		Days of effort	Hrs of observation	Nautical miles	Days of effort	Hrs of observation	Number of pods	No. of whales	No. of pods	No. of whales
1995	July	3	10:45	90	1	2:00	4	7	4	7
	August	14	63:45	484	12	40:35	16	34	24	34
	September	15	72:35	482	19	85:57	6	18	19	36
	Total	32	147:05	1056	32	128:32	26	59	47	77
1996	July	16	105:34	687	15	75:12	22	50	29	43
	August	27	195:27	1223	27	139:09	39	68	67	103
	September	13	79:46	651	10	63:22	3	9	8	15
	Total	56	380:47	2561	52	277:43	64	127	104	161
1997	July	15	93:30	333	14	67:08	25	47	32	46
	August	27	192:53	1325	27	146:47	27	57	33	51
	September	1	6:19	50	1	4:50	2	4	2	3
	Total	43	292:42	1708	42	218:45	54	108	67	100
1998	July	25	162:30	1280	27	115:27	11	27	13	25
	August	16	114:01	857	14	71:41	19	43	26	48
	September	9	63:35	549	10	47:04	10	19	16	27
	Total	50	340:06	2687	51	234:12	40	89	55	100
1999	July	22	139:02	1186	22	100:09	10	16	9	13
	August	23	169:03	1341	21	122:29	18	34	19	29
	September	1	4:00	54	0	0	0	0	0	0
	Total	46	308:05	2581	43	222:38	28	50	28	42
2000	July	17	123:45	926	16	73:34	16	26	10	17
	August	23	157:53	1190	18	94:08	24	49	21	36
	September	10	74:43	545	8	47:40	13	28	11	21
	Total	50	356:21	2661	42	215:22	53	103	42	74
TOTAL		277	1825:06	13254	262	1297:12	265	536	343	554

Population abundance was estimated across the six year study using mark-recapture photographic methodology allowing individual distinctiveness (see Friday et al., 2000) and the weighted mean of the Petersen estimate (Seber, 1982). Crude birth rates were calculated following Clapham & Mayo (1990).

Movements of humpback whales in the South Pacific area were established by comparing those identified in New Caledonia, until 1999, with those in published catalogues from east Australia ($n = 1,088$) (Kaufman et al., 1993), Tonga ($n = 247$) (Patenaude & Baker, 1996; unpubl. data) and New Zealand ($n = 4$) (Patenaude & Baker, 1996; unpubl. data) (Garrigue et al., 2000b). During a workshop held at the University of Auckland in March, 2000 (Donoghue & Baker, 2000) New Caledonian sightings were also compared with those identified in French Polynesia ($n = 138$) (Poole, unpubl. data), the

Cook Islands ($n = 23$) (Hauser & Peckham, unpubl. data), Colombia ($n = 20$) (Fundacion Yubarta, unpubl. data), Ecuador ($n = 59$) (Instituto Antartico Chileno, unpubl. data) and the Antarctic Peninsula ($n = 23$) (Instituto Antartico Chileno, unpubl. data).

RESULTS

SAMPLING AND DATA COLLECTION.

Sampling Effort. During the last six survey years a total of 277 days representing >1,800 hours were spent at sea and 262 days representing ~1,300 hours spent at the land observation point (Table 1).

A comparison of the number of pods seen by the land- and sea-based teams is shown in Fig. 2. Until 1998 more pods were observed from land than from sea but this pattern was reversed in 2000.

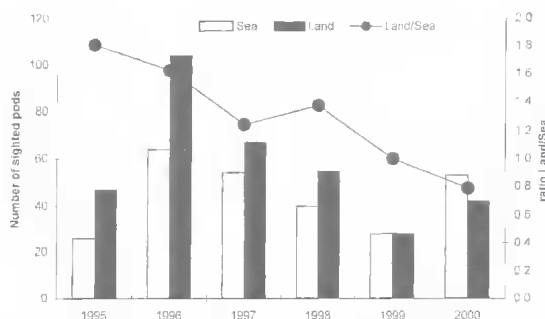


FIG. 2. Number of pods observed from land and sea.

Datasets and Collection. From >800 photographs 206 humpback whales were identified from the ventral surface of the flukes alone, or combined with dorsal fin/lateral body markings ($n = 202$), or by lateral body markings with dorsal fin alone ($n = 4$) (Garrigue & Greaves, 1999).

Two hundred and seventeen skin samples and 197 blubber samples were collected during the six-year study and are presently being analysed.

Songs were recorded since 1992 with ~60 recordings available for analysis. Some acoustic comparisons have been completed (Gill et al., 1995; Helweg et al., 1998; Helweg et al., 2000); others are in progress.

OCCURRENCE. Of the 466 marine mammal observation forms returned in the 9 years from 1991–1999, 269 included humpback whales, with sightings from all around New Caledonia. Earliest sightings predominated in June and the latest in December, although occasional sightings were recorded at other times (Fig. 3). Eighty per cent of reported observations were made in the winter (July, August and September) (Fig. 3). Data from the dedicated surveys of 1995–1999 show the peak of season was always in August, when >50% were observed (Fig. 3).

During land-based surveys, 343 pods comprising 554 whales were sighted. At sea, 265 pods comprising 536 whales were encountered over the six years. Monthly observations are summarised in Table 1. It should be noted that numbers decreased from 1996 until 1999 and that 1999 was particularly low (Fig. 4). The July 1995 survey was atypical, being 30 days later than for subsequent years.

POD OCCURRENCE, COMPOSITION, SIZE AND SIZE STRUCTURE. Social composition was recorded for 253 of the 265 pods sighted (Table 2). Over the six year survey the most commonly observed pod types were singles (39%)

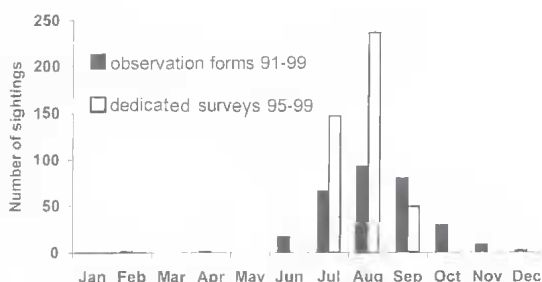


FIG. 3. Monthly observations of humpback whales.

and pairs (31%). Reproductive groups comprised 16% and mother-calf pairs 11%. Least represented groups were mother-calf and escort groups, and mother and calf in reproductive groups, comprising only 2% of encountered pods.

Mean pod size was 2.02.

Social composition of pods varied intra-seasonally (Fig. 5). In July, singles and pairs were more frequent; in August these were less frequent but mother-calf groups increased. In September this pattern was repeated along with an increase of reproductive groups including cows and calves; mother-calf and escort groups were also more common.

Whale sizes, although difficult to estimate, were classified using: small (for calf), medium (~8m or smaller) and large (>8m) (Table 3). During a season the population structure was dominated by large whales, representing >80%, except in 1999 when large whales were 64%, while medium-sized whales (24%) were seen in greater numbers than during previous years.

SEX COMPOSITION OF THE POPULATION. Skin samples were taken from 140 of the 206 identified whales and analysed for gender. Two percent of the samples gave inconclusive results; 65% of the sexed whales were male and 35%

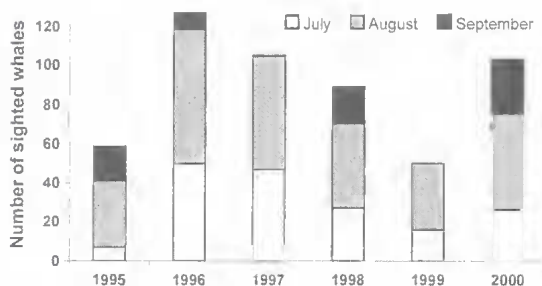


FIG. 4. Monthly observations of humpback whales by year of survey.

TABLE 2. Composition of sighted pods (Sn, single; Pr, pair; MC, mother and calf; MCE, mother, calf and escort; MC in CG, mother and calf in competitive group; CG, competitive group).

Year	Month	Sn	Pr	MC	MCE	MC in CG	CG
1995	July	1	2	0	0	0	1
	Aug	6	5	1	0	1	3
	Sept	1	2	0	1	0	2
	Total	8	9	1	1	1	6
1996	July	11	4	1	0	0	5
	Aug	15	13	5	0	0	3
	Sept	0	0	1	1	1	0
	Total	26	17	7	1	1	8
1997	July	11	9	0	0	0	2
	Aug	7	10	5	0	0	3
	Sept	1	2	0	0	0	0
	Total	19	21	5	0	0	5
1998	July	2	4	1	0	0	2
	Aug	9	3	1	0	0	6
	Sept	4	3	1	0	0	3
	Total	15	10	3	0	0	11
1999	July	4	3	2	0	0	0
	Aug	6	4	3	1	0	3
	Sept	0	0	0	0	0	0
	Total	10	7	5	1	0	3
2000	July	7	5	1	0	0	2
	Aug	9	8	3	0	1	4
	Sept	5	1	2	1	1	2
	Total	21	14	6	1	2	8
TOTAL		99	78	27	4	4	41

female. The sex-ratio was thus 1.9:1 in favour of males.

ESTIMATION OF ABUNDANCE AND CRUDE BIRTH RATE. From 1996 to 1998 the year-to-year re-sighting rate increased to >29%; decreasing to 5% in 1999 (Fig. 6). Forty six whales representing 22% of identified animals were re-sighted at least once, of which 50% were identified as males and 26% females. Not only were the same individuals sighted inter-annually, but they were observed several times intra-seasonally.

These observations suggest that the population is small. Using a weighted mean of the Petersen estimate the population was estimated at $N = 314$ (95% CI: 243-386) (Table 4). Crude birth rate was estimated following Clapham & Mayo (1990), at 3.4-10% (Table 5).

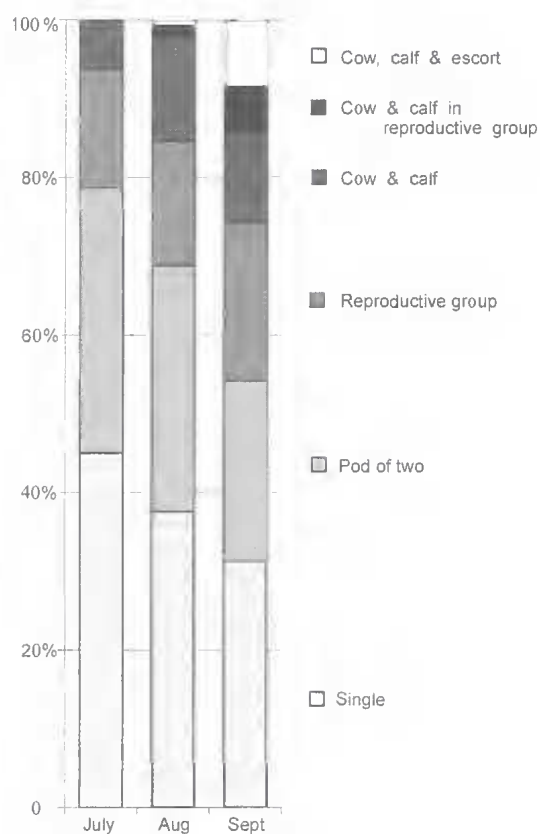


FIG 5. Monthly observations of social pods, 1995-2000.

INTRA-SEASONAL RESIGHTS. Fifty-nine whales, ~1/3 of identified individuals, were observed from 2-4 times during a single season. Most resights within a season were males (69% of the sexed whales) and the duration of stay was longer than that of females (average length of stay = 17 days for males and 10 days for females without calf). The maximum length of stay was 60 days by a male (observed on 7 July, 15 August and 5 September, suggesting residency for the

TABLE 3. Size structure of humpback whale sightings.

Year	No. of whales	% Small (calf)	% Medium	% Large
1995	35	8.5	8.5	83
1996	72	11	6	83
1997	72	5.5	14	80.5
1998	63	5	3	92
1999	41	12	24	64
2000	67	8	5	87
TOTAL	283	8	9	83

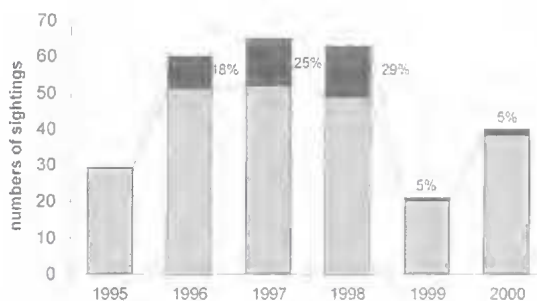


FIG. 6. Re-sighting rates (black).

entire period). The few females observed for a period >1 week were accompanied by calves.

MIGRATION. Ten humpback whales were sighted both at New Caledonia and another area of the South Pacific (Garrigue et al., 2000a, b). Seven were in migratory corridors (five in east Australia and two in New Zealand) and three during 1999 in the Tongan breeding grounds.

DISCUSSION

Humpback whales are present in New Caledonia during the austral winter. The seasonal peak is in August, earlier than in other more easterly breeding grounds such as Tonga, the Cook Islands and French Polynesia (M. Donoghue & N. Hauser, pers. comm.; Poole, pers. comm.). High numbers of opportunistic observations (marine mammal survey data) in September are probably explained by the occurrence of school holidays, and the usually mild weather conditions which favour recreational boating.

The presence of small, pale and uncoordinated calves, some with folded over dorsal fins, is evidence that the lagoon in the south of New Caledonia is a calving ground. Observation of reproductive groups and the acoustic detection of many singers provides evidence that this is also a mating area. The temporal usage pattern of this breeding ground by different social groups agrees with Chittleborough (1965) who concluded that certain age/sex classes of the population travel ahead of others. Our findings concerning the different length of stay of males and females concur with Matthews (1938) who suggested that mature females leave the breeding ground as soon as they are fertilised. The male-biased sex-ratio of the population has also been described on other breeding grounds (Dawbin & Falla, 1949; Brown et al., 1995).

The Area V stock of humpback whales is described by Dawbin (1966) as the group that

summer in the Antarctic between 130°E-170°W, then migrate past eastern Australia or New Zealand to reach their tropical winter breeding grounds. Photographic comparison of humpback whales seen in New Caledonia with those seen in Australia and New Zealand, and acoustic analyses of recordings from the three regions demonstrate that the population located around New Caledonia is a component of the Area V stock. In question is whether New Caledonia forms an extension of the east Australian group, or should be considered part of the New Zealand group as described by Dawbin (1966). The photo-ID comparison was not helpful in resolving this question, as exchanges were found with eastern Australia (5), New Zealand (2) and Tonga (3). Acoustic analysis demonstrated that east Australia and New Caledonia songs were not significantly different (Helweg et al., 1998). However, the demographic trend (i.e. no evidence of population increase) and the high re-sight rates within New Caledonia suggest a degree of subdivision between these regions. Genetic analyses currently in progress may answer this question.

The increase in inter-annual re-sighting rate from 1996 to 1998 suggests that the local population is not large. This is supported by the population estimate. This estimate must be interpreted with some caution as the Petersen method assumes that the population is closed with no immigration or emigration, yet our data show that there is some exchange between breeding grounds (Garrigue et al., 2000a, b). Equal 'catchability' of individuals in the population is another assumption that is possibly violated, as fluke photographing is largely opportunistic. For example, mothers with small calves seldom perform a fluke-up dive, which renders them temporarily unavailable for sampling. In any case, the estimate indicates that the abundance of humpback whales in New Caledonia is relatively low, numbering only a few hundred. This is in stark contrast to the situation off eastern Australia where the number of humpback whales passing along the coast has increased markedly over the last decade (Brown et al., 1997; Paterson et al. 1994, 2001) with a 1999 estimate of 3,600 individuals.

The smaller percentage of large whales observed in 1999 probably explains the low number of competitive groups that were also observed. This corroborates the weak acoustic detection rate (i.e. singing) in that period. The decrease in the ratio between pods seen from land and from sea needs further investigation. This decrease may be due

TABLE 4. Population estimates.

	1995	1996	1997	1998	1999	2000
Marked whales in current year (ni)	29	51	52	49	20	38
Number of recaptures (ni)	3	11	20	20	6	14
Marked whales from previous years (Mi)	27	53	93	125	154	167
N (estimate)						314

to: an effect of the observers and/or of weather conditions; improved sighting skill of the vessel-based team; a shift of whales further off-shore (possibly related to the unregulated development of whale watching cruises); or other causes. These results, when considered with the inter-annual resighting rate and the increase of crude birth rate in 1999 and 2000, demonstrate a change in the characteristics of the New Caledonian humpback whale population.

Results of the six-year dedicated survey show that the southern part of the New Caledonian lagoon is a breeding ground for humpback whales during the austral winter. It is known that other parts of the large lagoon bounding the main island are also used. Ouvéa and isolated atolls, such as the Chesterfield area (~600kmNW of the study site) (cited by Townsend, 1935 as a whaling ground) and Surprise (NW New Caledonia) are also possible breeding grounds. Future research should confirm this. The study of humpback whales in New Caledonia (including collection of photo-ID, skin and blubber samples, song recordings and behavioural data) will continue in order to contribute to a larger survey of humpback whales in the tropical South Pacific (Anonym., 2001). A comparison of genetic samples and photo-ID data collected over a wide area, including eastern Australia, New Zealand, New Caledonia, Tonga, Cook Islands and French Polynesia, will improve knowledge of humpback whales in the South Pacific.

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TABLE 5. Crude birth rate.

Year	Number of Calves (Tc)	Number of sighted whales (Ti)	Tc/Ti %
1995	3	59	5.1
1996	8	127	6.3
1997	4	108	3.7
1998	3	89	3.4
1999	5	50	10.0
2000	9	103	8.7
Mean	5	89	6.0

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LITERATURE CITED

- ANONYMOUS, 2001. Report of the Annual Meeting of the South Pacific Whale Research Consortium. (South Pacific Whale Research Consortium: Rarotonga, Cook Islands).
- BAKER, C.S. & HERMAN, L.M. 1984. Aggressive behavior between humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Canadian Journal of Zoology* 72: 274-279.
- BROWN, M.R., CORKERON, P.J., HALE, P.T., SCHULTZ, W. & BRYDEN, M.M. 1995. Evidence for a sex-segregated migration in the humpback whale (*Megaptera novaeangliae*). *Proceedings of the Royal Society of London B* 259: 229-234.
- BROWN, M.R., FIELD, M.S., CLARKE, E.D., BUTTERWORTH, D.S. & BRYDEN, M.M. 1997. Estimates of abundance and rate increase for east Australian humpback whales from the 1996 land-based survey at Point Lookout, North Stradbroke Island, Queensland. SC/49/SH35.
- CHITTLEBOROUGH, R.G. 1965. Dynamics of two populations of the humpback whale, *Megaptera novaeangliae* (Borowski). *Australian Journal of Marine and Freshwater Research* 16(1): 33-128.
- CLAPHAM, P.J. & MAYO, C.A. 1990. Reproduction of humpback whales (*Megaptera novaeangliae*) observed in the gulf of Maine. *Reports of the International Whaling Commission*. (Special Issue 12): 171-175.
- CLAPHAM, P.J., PALSBOILL, P.J., MATTILA, D.K. & VASQUEZ, O. 1992. Composition and dynamics of humpback whale competitive groups in the West Indies. *Behaviour* 122: 182-194.
- DAWBIN, W.H. 1966. The seasonal migratory cycle of humpback whales. Pp. 145-170. In Norris, K.S. (ed.) *Whales, dolphins and porpoises*. (University of California Press: Los Angeles).
- DAWBIN, W.H. & FALLA, R.A. 1949. A contribution to the study of the humpback whale based on observations at New Zealand shore stations.

- Proceedings of the 7th Pacific Science Congress of the Pacific Science Association: 373-382.
- DONOGHUE, M.F. & BAKER, C.S. (conveners) 2000. Report on a workshop on humpback whales in Oceania. (University of Auckland: Auckland, New Zealand).
- FRIDAY N.A., SMITH T.D., STEVICK P.T. & ALLEN, J. 2000. Measurement of photographic quality and individual distinctiveness for the photographic identification of humpback whales, *Megaptera novaeangliae*. *Marine Mammal Science* 16(2): 355-374.
- GARRIGUE, C. & GREAVES, J. 1999. New Caledonia, a rendezvous for the humpback whale. In: Ledru, C. (ed.) *New Caledonia*. (Singapore).
2001. Cetacean records for the New Caledonian area (South West Pacific). *Micronesica* 24(1): 27-33.
- GARRIGUE, C. & GILL, P. 1994. Observations of humpback whales (*Megaptera novaeangliae*) in New Caledonian waters during 1991-1993. *Biological Conservation* 70(3): 211-218.
- GARRIGUE C., AGUAYO, A., BAKER, C.S., CABALLERO, S., CLAPHAM, P., CONSTANTINE, R., DENKINGER, J., DONOGHUE, M., FLÓREZ-GONZÁLEZ, L., GREAVES, J., HAUSER, N., OLAVARRIA, C., PAIROA, C., PECKHAM, H. & POOLE, M. 2000a. Movements of humpback whales in Oceania, South Pacific. Scientific paper presented at International Whaling Commission SC/52/IA6.
- GARRIGUE, C., FORESTELL, P., GREAVES, J., GILL, P., NAEISSIG, P., BAKER, C.S. & PATENAUDE, N. 2000b. Migratory movement of humpback whales (*Megaptera novaeangliae*) between New Caledonia, east Australia and New Zealand. *Journal of Cetacean Research and Management* 2(2): 111-115.
- GILSON A. & SYVANEN, M. 1998. Deer gender determination by polymerase chain reaction: validation study and application to tissues, bloodstains and hair forensic samples from California. *California Fish and Game* 84(4): 59-69.
- GILL, P., EYRE, E., GARRIGUE, C. & DAWBIN, W.H. 1995. Observations of humpback whales (*Megaptera novaeangliae*) on a cruise to New Caledonia and the Chesterfield reefs. *Memoirs of Queensland Museum* 38(2): 505-511.
- HELWEG, D.A., CATO, D.H., JENKINS, P.J., GARRIGUE, C. & McCAULEY, R.D. 1998. Geographic variation in South Pacific humpback whale songs. *Behaviour* 135: 1-27.
- KATONA, S., BAXTER, B., BRAZIER, O., KRAUS, S., PERKINS, J. & WHITEHEAD, H. 1979. Identification of humpback whales by fluke photographs. Pp. 33-44. In Winn, H.E. & Olla, B.L. (eds) *Behaviour of marine animals Vol. 3*. (Plenum Press: New York).
- KAUFMAN, G.D., LAGERQUIST, B.A., FORESTELL, P.H. & OSMOND, M.G. 1993. Humpback whales of Australia: a catalogue of individual whales identified by fluke photographs. (Queensland Department of Environment and Heritage: Brisbane).
- LAMBERTSEN, R.H., BAKER, C.S., WEINRICH, M. & Modi, W.S. 1994. An improved whale biopsy system designed for multidisciplinary research. Pp. 219-244. In Fossi, C. & Leonzio, C. (eds) *Non destructive biomarkers in vertebrates*. (Lewis Publishers: London).
- MATTHEWS, L.H. 1938. The humpback whale, *Megaptera nodosa*. *Discovery Reports* 17: 7-92.
- PATENAUDE, N. & BAKER, C.S. (eds) 1996. An individual identification of humpback whales (*Megaptera novaeangliae*) in Tonga 1991-1995. Unpubl. report to the Whale and Dolphin Conservation Society, Pacific Development Trust and the South Pacific Regional Environment Program.
- PATERSON, R., PATERSON, P. & CATO, D.H. 1994. The status of humpback whales (*Megaptera novaeangliae*) in east Australia thirty years after whaling. *Biological Conservation* 70: 135-142.
2001. Status of humpback whales *Megaptera novaeangliae* in east Australia at the end of the 20th century. *Memoirs of the Queensland Museum* 47(2): 579-586.
- PISIER, G. 1975. Les aventures du Capitaine Cheyne dans l'archipel Calédonien 1841-1842. Publications de la Société d'Etudes Historiques de la Nouvelle-Calédonie, Nouméa, 49p.
- ROSENBAUM H.C., RAZAFINDRAKOTO, Y., FLÓREZ-GONZÁLEZ, L., CAPELLA, J., GARRIGUE, C., GREAVES, J., JENNER, C., JENNER, M-N., ROBLES-SAAVEDRA, M.R., DESALLE, R. & BAKER, C.S. 1998. Variation and geographic structure of humpback whale mitochondrial DNA from the wintering grounds of Areas III, IV, V and VI in the Southern Hemisphere. Scientific paper presented at International Whaling Commission SC/50/CAWS35.
- SEBER, G.A.F. 1982. The estimation of animal abundance and related parameters. 2nd Edn. (Charles Griffin & Co.: London).
- TOWNSEND, C.H. 1935. The distribution of certain whales as shown by logbook records of American Whaleships. *Zoologica* 19: 105-116.
- TYACK, P. & WHITEHEAD, H. 1983. Male competition in large groups of wintering humpback whales. *Behaviour* 83: 1-23.